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HYMENOPTERA REARED FROM *PLAGIOTROCHUS SUBERI* (HYMENOPTERA: CYNIPIDAE) GALLS IN CALIFORNIA

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Abstract.—Nine species of Hymenoptera were reared from stem galls induced by *Plagiotrochus suberi* Weld on *Quercus suber* L. in Albany, California. The most numerous species reared was *P. suberi*, but *Euderus crawfordi* Peck was the most common parasitoid reared. Other species reared were: *Aprostocetus pattersonae* (Fullaway), *A.* sp. nr. *verrucarii* (Balduf), *Acaenacis taciti* (Girault), *Sycophila wiltzae* (Balduf), *Sycophila* sp. possibly *foliatae* (Ashmead), *Brasema* sp. and *Ceraphron* sp. The rearings of all parasitoids (except *E. crawfordi* and *S. wiltzae*) constitute new host records. All described parasitoid species are native to North America and represent new associations with the introduced *P. suberi*.

Key Words.—Insecta, *Plagiotrochus suberi*, *Quercus suber*, *Euderus crawfordi*, new associations, parasitoids

Plagiotrochus suberi Weld (Hymenoptera: Cynipidae) was first described by Weld (1926) from specimens collected in California. It is restricted to cork oak (*Quercus suber* L.) and it produces intrinsic stem galls on the twigs, occasionally resulting in economic damage (Essig 1943). Weld (1926) suggested the cynipid was a native Nearctic species that shifted hosts when cork oaks were introduced from Europe, but Kinsey (1935) disagreed and considered it to be the agamic form of some unspecified European species. The latter view was confirmed when *P. suberi* was found in Switzerland in 1957 and in Portugal in 1963 (Bailey & Stange 1966). It has since been reported from Argentina (Diaz 1972).

The biology of *P. suberi* was reported by Bailey & Stange (1966) based on studies in Davis, California. The only parasitoid they found associated with *P. suberi* was *Euderus crawfordi* Peck (Hymenoptera: Eulophidae).

The presence of *P. suberi* on cork oaks at our experiment station provided an opportunity to study the guild of Hymenoptera associated with the galls. This paper reports the species of Hymenoptera reared, and their relative abundance and chronology of emergence.

MATERIALS AND METHODS

Two *Q. suber* trees located at the University of California, Berkeley's Gill Tract in Albany, California were sampled from 1992–1994. All samples were randomly chosen from the distal ends of branches accessible from the ground or a 3 m stepladder. Twigs with swellings or emergence holes were broken into pieces about 7.5 cm long and placed in shell vials stoppered with cotton. These twigs ranged from 1.5–8 mm in width, and emergence holes were noted in twigs that were 2–8 mm wide.

In 1992 about 100 twigs were collected on 5 May; these were held inside at room temperature until 9 May 1993. The trees were sampled eight times (every 1–2 weeks) between 24 Feb and 14 May 1993. Approximately 10–20 twigs were

Table 1. Number of adult Hymenoptera emerging from *Quercus suber* twigs, collected in Albany, California, 1992–1994.

Year	Species	Date of emergence						Total
		27 Mar–30 Apr	1 May–7 May	8 May–14 May	15 May–21 May	22 May–28 May	29 May–16 Jul	
1992[a]	*P. suberi*	—[d]	—	+++	+++	+	0	ca. 150
	E. crawfordi	—	—	33	9	5	2	49
	Other species	—	—	0	0	3	10	13
1993[b]	*P. suberi*	0	7	24	53	29	2	115
	E. crawfordi	8	1	3	3	3	3	21
	Other species	9	0	0	0	1	1	11
1994[c]	*P. suberi*	0	1	10	10	49	96	166
	E. crawfordi	59	13	15	5	5	15	112
	Other species	29	1	7	0	3	8	48

[a] From 100 twigs, collected on 5 May, 1992.
[b] From ca. 120 twigs, collected 24 Feb–14 May, 1993.
[c] From 1809 twigs, collected 27 Jan–26 May, 1994.
[d] — = not sampled; +++ = many; + = few.

collected each time. In 1994, 10 twigs were collected once per week from 27 Jan to 26 May (18 total samples). The 1993 and 1994 samples were held outside, shaded from direct sunlight, until 30 July of each year. The number, sex and dates of emergence of adults were recorded for all species (except in 1992, when numbers of *P. suberi* were only estimated).

Results

In all years *P. suberi* was the most common species reared, its 400+ adults accounting for about 63% of all emergents (Table 1). The chronology of *P. suberi* emergence was similar each year, peaking in May. No cynipids emerged from samples collected in February or March. The earliest emergence in any season was on 2 May 1994, and the latest on 16 Jun 1994. Only females were found. The exact number of adults emerging from each twig was not recorded, but samples collected in April or May produced an approximate mean number of 1.5 adults per twig in 1992, 1.53 in 1993, and 2.08 in 1994. The highest rate was 8.2 adults per twig, from a sample collected in mid-May 1994.

Euderus crawfordi was the most common parasitoid reared, representing 23% of all emergents in 1992, 14% in 1993 and 34% in 1994. In 1992, emergence by this species peaked in the first half of May. In 1993, low numbers emerged steadily throughout the spring with no distinct peak, and in 1994, emergence peaked in mid-April. This was the only species reared from twigs collected during all 26 sampling periods in 1993 and 1994. One female emerged from a twig over 5 months after collection (27 Jan to 6 Jun 1994), and one male emerged over 4 months later (3 Feb to 14 Jun 1994).

Nine *Aprostocetus pattersonae* (Fullaway) (Hymenoptera: Eulophidae) emerged in June 1992 and two in July 1994. This species emerged only from twigs collected in May. Eight *A.* sp. nr. *verrucarii* (Balduf) were reared in April 1993 (twigs collected from March–April) and 31 from April–May 1994 (collected January–April).

Three females and one male *Acaenacis taciti* (Girault) (Hymenoptera: Pteromalidae) were reared in May 1992, and a single male in June 1993 (collected in May). A male *Brasema* sp. (Hymenoptera: Eupelmidae) emerged in May 1993 (collected in May), and two females and nine males in May–June 1994 (collected from January–May). In 1994, two female and one male *Sycophila wiltzae* (Balduf), and a female *Sycophila* sp. possibly *foliatae* (Ashmead) (Hymenoptera: Eurytomidae) were reared in May (all collected in May). A single *Ceraphron* sp. female (Hymenoptera: Ceraphronidae) emerged in April 1993.

Discussion

The emergence pattern of *P. suberi* reported here agrees with that reported by Bailey & Stange (1966). The absence of cynipid emergence from the samples collected in February and March is probably due to larval mortality brought about by the removal of the twigs from the trees. This species pupates in April, after which any change in its substrate would have a decreased impact.

Bailey & Stange (1966) calculated that the average number of twig wasp exit holes over 7 years ranged from 0.4 to 3.0 per linear cm of twig. From twigs collected in April or May, I reared approximately 0.2 to 0.3 *P. suberi* adults per cm. Two factors help explain this discrepancy. First, Bailey & Stange may have overestimated *P. suberi* numbers if they did not distinguish exit holes made by *E. crawfordi.* Second, my methods underestimate *P. suberi,* because additional adults might have emerged prior to collection, or died without emerging due to trauma caused by the breaking of the twig. The density of exit holes I observed in this study appeared similar to that pictured in Figure 4 of Bailey & Stange (1966).

Albany may also have a higher parasitoid population than Davis. Bailey & Stange (1966) noted that *E. crawfordi* reached "high numbers" in one tree, but appeared to be of little importance in limiting the cynipid's populations. In the present study, the ratio of emergent *E. crawfordi* to *P. suberi* reached 1:3 in 1992, and 2:3 in 1994.

Euderus crawfordi is known only from California and Arizona, and its only other recorded host is *Dryocosmus coxii* (Bassett) (Hymenoptera: Cynipidae) (Yoshimoto 1971). *Dryocosmus coxii* is closely related to *P. suberi* and produces stem galls on *Quercus emoryi* Torrey and *Q. hypoleuca* Engelmann in Arizona and New Mexico (Burks 1979). The parasitoid may have moved over onto *P. suberi* when the latter was introduced through the planting of *Q. suber* in the southwestern United States. Although I made no direct observations of parasitization, the emergence pattern and relatively high numbers of *E. crawfordi* support its characterization as a primary parasitoid.

Both *Aprostocetus* species belong to the subgenus *Quercastichus* LaSalle, which is known only from cynipid galls on oaks in North America (LaSalle 1994). *Sycophila wiltzae* was reared from undetermined galls on *Q. suber* in San Jose in 1918 (Balduf 1932). The cynipids issuing from this material (= Hopkins U.S. No. 15608a) were eventually determined to be *P. suberi* (Weld 1926). *Sycophila wiltzae* has also been reared from *Andricus wiltzae* Fullaway galls on Q. *lobata* Nee (Balduf 1932). The second *Sycophila* species resembles *S. foliatae,* which has been reared from four genera of gall-forming cynipids on oaks in the eastern United States (Burks 1979).

The rearings reported here represent new host associations for both *Aprostocetus* species, *A. taciti, Sycophila* sp., *Braesma* sp. and *Ceraphron* sp.

Plagiotrochus suberi is uncommon in Europe: although its sole known host is native there, the cynipid was unknown there until 39 years after its description in the New World (Bailey & Stange 1966). In contrast, the cynipid is common throughout California (Essig 1943). This is a relatively recent introduction, with the first collection made in 1918 (Weld 1926). In 1966, Bailey & Stange noted that *Q. suber* in Davis had appeared to be pest-free since about 1930, but "in recent years" had begun to deteriorate due to the cynipid's activity. They concluded that *E. crawfordi* does not provide control of *P. suberi.*

Although the endemic natural enemy complex appears to be better-developed in Albany than in Davis, the cynipid is still very numerous here. There are also no records of natural enemies of *P. suberi* from Europe. This does not necessarily indicate an absence of such organisms, but more likely is a reflection of the relative scarceness of the cynipid itself.

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